# EXPERIMENT 2

## AIM

Use of screw gauge to

(a) measure diameter of a given wire,

(b) measure thickness of a given sheet; and

(c) determine volume of an irregular lamina.

## APPARATUS AND MATERIAL REQUIRED

Wire, metallic sheet, irregular lamina, millimetre graph paper, pencil and screw gauge.

## DESCRIPTION OF APPARATUS

With Vernier Callipers, you are usually able to measure length accurately up to 0.1 mm. More accurate measurement of length, up to 0.01 mm or 0.005 mm, may be made by using a screw gauge. As such a Screw Gauge is an instrument of higher precision than a Vernier Callipers. You might have observed an ordinary screw [Fig E2.1 (a)]. There are threads on a screw. The separation between any two consecutive threads is the same. The screw can be moved backward or forward in its nut by rotating it anti-clockwise or clockwise [Fig E2.1(b)].

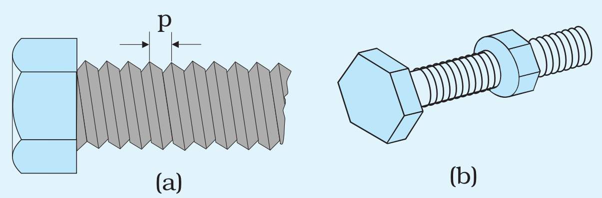


***Fig.E 2.1*** *A screw (a) without nut (b) with nut*

The distance advanced by the screw when it makes its one complete rotation is the separation between two consecutive threads. This distance is called the Pitch of the screw. Fig. E 2.1(a) shows the pitch ($p$) of the screw. It is usually 1 mm or 0.5 mm. Fig. E 2.2 shows a screw gauge. It has a screw 'S' which advances forward or backward as one rotates the head C through rachet R. There is a linear

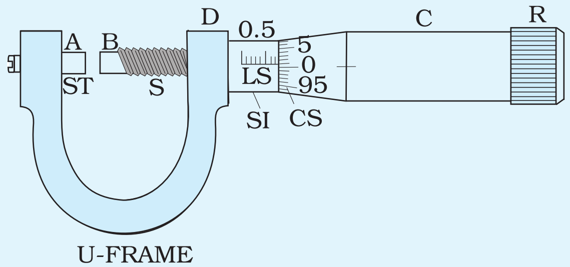


***Fig.E 2.2:*** *View of a screw gauge*

scale 'LS' attached to limb D of the U frame. The smallest division on the linear scale is 1 mm (in one type of screw gauge). There is a circular scale CS on the head, which can be rotated. There are 100 divisions on the circular scale. When the end B of the screw touches the surface A of the stud ST, the zero marks on the main scale and the circular scale should coincide with each other.

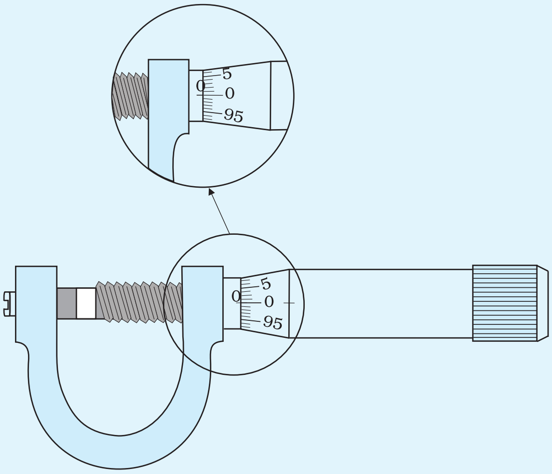


***Fig.E 2.3:*** *A screw gauge with no zero error*

## ZERO ERROR

When the end of the screw and the surface of the stud are in contact with each other, the linear scale and the circular scale reading should be zero. In case this is not so, the screw gauge is said to have an error called zero error.

Fig. E 2.3 shows an enlarged view of a screw gauge with its faces A and B in contact. Here, the zero mark of the LS and the CS are coinciding with each other.

When the reading on the circular scale across the linear scale is more than zero (or positive), the instrument has **Positive zero error** as shown in Fig. E 2.4 (a). When the reading of the circular scale across the linear scale is less than zero (or negative), the instrument is said to have **negative zero error** as shown in Fig. E 2.4 (b).



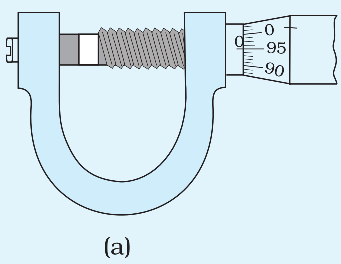


***Fig.E 2.4 (a):*** *Showing a positive zero error*

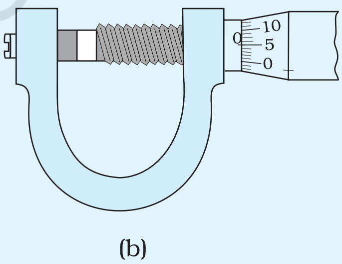


***Fig.E 2.4 (b):*** *Showing a negative zero error*

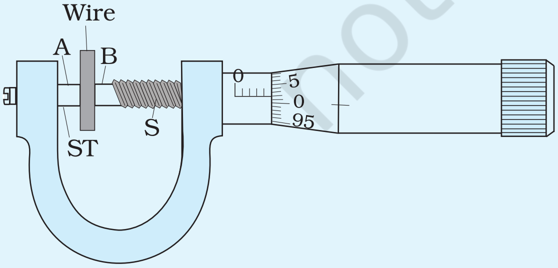


***Fig.E 2.5:*** *Measuring thickness with a screw guage*

## TAKING THE LINEAR SCALE READING

The mark on the linear scale which lies close to the left edge of the circular scale is the linear scale reading. For example, the linear scale reading as shown in Fig. E 2.5, is 0.5 cm.

## TAKING CIRCULAR SCALE READING

The division of circular scale which coincides with the main scale line is the reading of circular scale. For example, in the Fig. E 2.5, the circular scale reading is 2.

**TOTAL READING**

Total reading

= linear scale reading + circular scale reading × least count

= 0.5 + 2 × 0.001

= 0.502 cm

## PRINCIPLE

The linear distance moved by the screw is directly proportional to the rotation given to it. The linear distance moved by the screw when it is rotated by one division of the circular scale, is the least distance that can be measured accurately by the instrument. It is called the least count of the instrument.

$$\text{Least count} = \frac{\text{pitch}}{\text{No. of divisions on circular scale}}$$

For example for a screw gauge with a pitch of 1mm and 100 divisions on the circular scale. The least count is

$$1 \text{ mm}/100 = 0.01 \text{ mm}$$

This is the smallest length one can measure with this screw gauge.

In another type of screw gauge, pitch is 0.5 mm and there are 50 divisions on the circular scale. The least count of this screw gauge is 0.5 mm/50 = 0.01 mm. Note that here two rotations of the circular scale make the screw to advance through a distance of 1 mm. Some screw gauge have a least count of 0.001 mm (i.e. $10^{-6}$ m) and therefore are called micrometer screw.

**(a) Measurement of Diameter of a Given Wire**

## PROCEDURE

1. Take the screw gauge and make sure that the rachet R on the head of the screw functions properly.
2. Rotate the screw through, say, ten complete rotations and observe the distance through which it has receded. This distance is the reading on the linear scale marked by the edge of the circular scale. Then, find the pitch of the screw, i.e., the distance moved by the screw in one complete rotation. If there are n divisions on the circular scale, then distance moved by the screw when it is rotated through one division on the circular scale is called the least count of the screw gauge, that is,

$$\text{Least count} = \frac{\text{pitch}}{n}$$

3. Insert the given wire between the screw and the stud of the screw gauge. Move the screw forward by rotating the rachet till the wire is gently gripped between the screw and the stud as shown in Fig. E 2.5. Stop rotating the rachet the moment you hear a click sound.

4. Take the readings on the linear scale and the circular scale.

5. From these two readings, obtain the diameter of the wire.

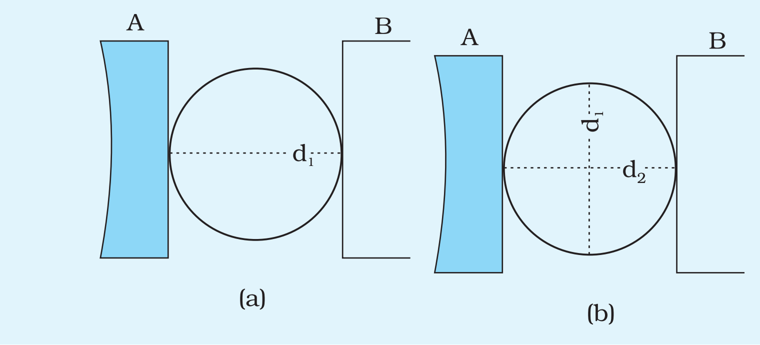


**Fig.E 2.6 (a):** *Two magnified views (a) and (b) of a wire showing its perpendicular diameters $d_1$ and $d_2$. $d_2$ is obtained after the rotating the wire in the clockwise direction through 90°.*

6. The wire may not have an exactly circular cross-section. Therefore. it is necessary to measure the diameter of the wire for two positions at right angles to each other. For this, first record the reading of diameter $d_1$ [Fig. E 2.6 (a)] and then rotate the wire through 90° at the same cross-sectional position. Record the reading for diameter $d_2$ in this position [Fig. E 2.6 (b)].

7. The wire may not be truly cylindrical. Therefore, it is necessary to measure the diameter at several different places and obtain the average value of diameter. For this, repeat the steps (3) to (6) for three more positions of the wire.

8. Take the mean of the different values of diameter so obtained.

9. Substract zero error, if any, with proper sign to get the corrected value for the diameter of the wire.

## OBSERVATIONS AND CALCULATION

The length of the smallest division on the linear scale = ... mm

Distance moved by the screw when it is rotated through $x$ complete rotations, $y$ = ... mm

Pitch of the screw = $\frac{y}{x}$ = ... mm

Number of divisions on the circular scale $n$ = ...

Least Count (L.C.) of screw guage

$$= \frac{pitch}{No.\ of\ divisions\ on\ the\ circular\ scale} = \ldots \text{ mm}$$

Zero error with sign (No. of div. × L. C.) = ... mm

**Table E 2.1: Measurement of the diameter of the wire**

| S. No. | Reading along one direction ($d_1$) | | | Reading along perpendicular direction ($d_2$) | | | Measured diameter $d = \frac{d_1 + d_2}{2}$ |
|---|---|---|---|---|---|---|---|
| | Linear scale reading $M$ (mm) | Circular scale reading ($n$) | Diameter $d_1 = M + n \times$ L.C. (mm) | Linear scale reading $M$ (mm) | Circular scale reading ($n$) | Diameter $d_2 = M + n \times$ L.C. (mm) | |
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |

Mean diameter = ... mm

Mean corrected value of diameter

= measured diameter – (zero error with sign) = ... mm

## RESULT

The diameter of the given wire as measured by screw gauge is ... m.

## PRECAUTIONS

1. Rachet arrangement in screw gauge must be utilised to avoid undue pressure on the wire as this may change the diameter.
2. Move the screw in one direction else the screw may develop "play".
3. Screw should move freely without friction.
4. Reading should be taken atleast at four different points along the length of the wire.
5. View all the reading keeping the eye perpendicular to the scale to avoid error due to parallax.

## SOURCES OF ERROR

1. The wire may not be of uniform cross-section.
2. Error due to backlash though can be minimised but cannot be completely eliminated.

### BACKLASH ERROR

In a good instrument (either screw gauge or a spherometer) the thread on the screw and that on the nut (in which the screw moves), should tightly fit with each other. However, with repeated use, the threads of both the screw and the nut may get worn out. As a result a gap develops between these two threads, which is called "play". The play in the threads may introduce an error in measurement in devices like screw gauge. This error is called backlash error. In instruments having backlash error, the screw slips a small linear distance without rotation. To prevent this, it is advised that the screw should be moved in only one direction while taking measurements.

3. The divisions on the linear scale and the circular scale may not be evenly spaced.

## DISCUSSION

1. Try to assess if the value of diameter obtained by you is realistic or not. There may be an error by a factor of 10 or 100 . You can obtain a very rough estimation of the diameter of the wire by measuring its thickness with an ordinary metre scale.
2. Why does a screw gauge develop backlash error with use?

## SELF ASSESSMENT

1. Is the screw gauge with smaller least count always better? If you are given two screw gauges, one with 100 divisions on circular scale and another with 200 divisions, which one would you prefer and why?
2. Is there a situation in which the linear distance moved by the screw is not proportional to the rotation given to it?
3. Is it possible that the zero of circular scale lies above the zero line of main scale, yet the error is positive zero error?
4. For measurement of small lengths, why do we prefer screw gauge over Vernier Callipers?

**SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES**

1. Think of a method to find the 'pitch' of bottle caps.
2. Compare the 'pitch' of an ordinary screw with that of a screw guage. In what ways are the two different?
3. Measure the diameters of petioles (stem which holds the leaf) of different leaf and check if it has any relation with the mass or surface area of the leaf. Let the petiole dry before measuring its diameter by screw gauge.





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4. Measure the thickness of the sheet of stainless steel glasses of various make and relate it to their price structure.
5. Measure the pitch of the 'screw' end of different types of hooks and check if it has any relation with the weight each one of these hooks are expected to hold.
6. Measure the thickness of different glass bangles available in the Market. Are they made as per some standard?
7. Collect from the market, wires of different gauge numbers, measure their diameters and relate the two. Find out various uses of wires of each gauge number.

**(b) Measurement of Thickness of a Given Sheet**

## PROCEDURE

1. Insert the given sheet between the studs of the screw gauge and determine the thickness at five different positions.
2. Find the average thickness and calculate the correct thickness by applying zero error following the steps followed earlier.

## OBSERVATIONS AND CALCULATION

Least count of screw gauge = ... mm

Zero error of screw gauge = ... mm

**Table E 2.2 Measurement of thickness of sheet**

| S. No. | Linear scale reading $M$ (mm) | Circular scale reading $n$ | Thickness $t = M + n \times$ L.C. (mm) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Mean thickness of the given sheet = ... mm

Mean corrected thickness of the given sheet

= observed mean thickness – (zero error with sign) = ... mm

## RESULT

The thickness of the given sheet is ... m.

## SOURCES OF ERROR

1. The sheet may not be of uniform thickness.
2. Error due to backlash though can be minimised but cannot be eliminated completely.

## DISCUSSION

1. Assess whether the thickness of sheet measured by you is realistic or not. You may take a pile of say 20 sheets, and find its thickness using a metre scale and then calculate the thickness of one sheet.
2. What are the limitations of the screw gauge if it is used to measure the thickness of a thick cardboard sheet?

**SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES**

1. Find out the thickness of different wood ply boards available in the market and verify them with the specifications provided by the supplier.
2. Measure the thickness of the steel sheets used in steel almirahs manufactured by different suppliers and compare their prices. Is it better to pay for a steel almirah by mass or by the guage of steel sheets used?
3. Design a cardboard box for packing 144 sheets of paper and give its dimensions.
4. Hold 30 pages of your practical notebook between the screw and the stud and measure its thickness to find the thickness of one sheet.
5. Find the thickness of plastic ruler/metal sheet of the geometry box.

**(C) Determination of Volume of the Given Irregular Lamina**

## PROCEDURE

1. Find the thickness of lamina as in Experiment E 2(b).
2. Place the irregular lamina on a sheet of paper with mm graph. Draw the outline of the lamina using a sharp pencil. Count the total number of squares and also more than half squares within the boundary of the lamina and determine the area of the lamina.
3. Obtain the volume of the lamina using the relation mean thickness × area of lamina.

## OBSERVATIONS AND CALCULATION

Same as in Experiment E 2(b). The first section of the table is now for readings of thickness at five different places along the edge of the

lamina. Calculate the mean thickness and make correction for zero error, if any.

From the outline drawn on the graph paper:-

Total number of complete squares = ... $mm^2$ = ... $cm^2$

Volume of the lamina = ... $mm^3$ = ... $cm^3$

## RESULT

Volume of the given lamina = ... $cm^3$

### SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

1. Find the density of cardboard.
2. Find the volume of a leaf (neem, bryophyte).
3. Find the volume of a cylindrical pencil.